U T A H   G E O L O G I C A L   S U R V E Y

SURVEY NOTES

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Discovering Early American Lifestyles on Dugway Proving Grounds

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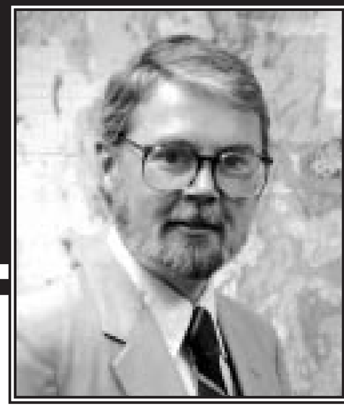

The Director's Perspective

by M. Lee Allison

What do we do with the monument?

The battle over what we do with the recently established Grand Staircase-Escalante National Monument (GSENM) is being fought to a certain extent in the press and in the courts. However, the monument planning team initiated a series of formal public scoping hearings to incorporate ideas on how the monument is to be managed. Management philosophies can be grouped into three simplified approaches: resource development, tourism development, or wilderness preservation.

Given the approaches that are used in existing national parks and monuments, it is unlikely that one of the above three will be adopted to the exclusion of the others. The big questions then is, what is the appropriate balance among them? For those who would argue that no resource development should be allowed in the monument, it must be noted that 584 oil and gas operations and 31 mining operations are currently active in national parks and monuments around the country today. I have to add that none of the oil and gas wells are drilled on federal surface acreage in the park units. Instead, they are operating on non-federal lands inside the parks (similar to the school trust lands surrounded and isolated inside the GSENM) or are drilled from outside the park boundaries to leases under federal lands within park boundaries. The inclusion of part of the Upper Valley oil field into the GSENM established a precedent: the first-ever producing oil wells on federal surface lands within a national monument. The oil field crosses a boundary to the monument. It is not unreasonable to ask, if resource development is so incompatible with a national monument, why was an oil field included in this one?

The Utah Geological Survey has been vocal and aggressive in pointing out the energy and mineral resources in the monument and the potential for development. The reason we do this is that the UGS is mandated by State statute to:

> "investigate the kind, amount, and availability of the various mineral substances contained in state lands, so as to contribute to the most effective and beneficial administration of these lands for the state," and

> "study and analyze other scientific, economic, or aesthetic problems...to serve the needs of the state and to support the development of natural resources and utilization of lands within the state."

In addition, certain state funds are allocated to the UGS specifically;

> "to be used for activities carried on by the survey having as a purpose the development and exploitation of natural resources in the state of Utah."

However much historical precedent there is for resource development in similar situations, it is arguable

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Discovering Early American Lifestyles on Dugway Proving Grounds

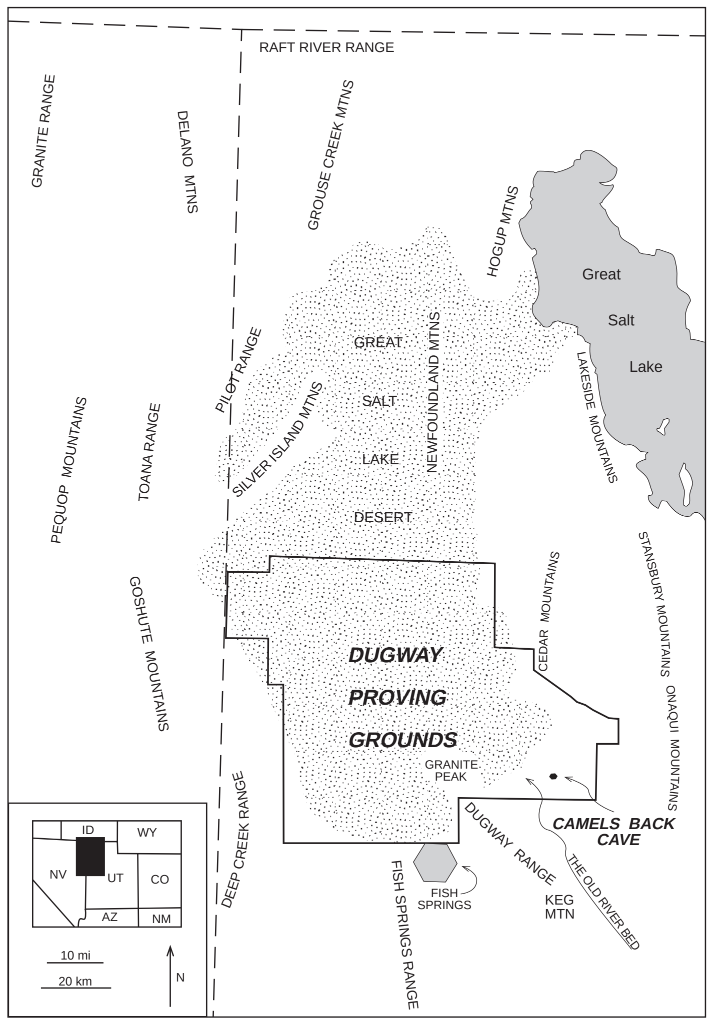
by Monson Shaver

The Paleoecology and Archaeology Section of the Environmental Sciences Program at the Utah Geological Survey is currently involved in a long-term cooperative project with the Department of Defense at Dugway Proving Grounds in Tooele County, Utah. This project focuses on the stratified deposits (alternating layers of dust, vegetation, cultural artifacts, and roof spall) of Camels Back Cave and is intended to provide a background chronology for the surrounding historic and prehistoric archaeological sites currently being documented on lands controlled by the U.S. Army. Beyond meeting these basic management needs, we hope to use the unique nature of the cave deposits to investigate the material remains left during short-term occupations by mobile hunter-gatherers in the Bonneville Basin.

In 1993, paleoenvironmental work on Dugway Proving Grounds was conducted to test the nature of floral and faunal records in the dry, stratified caves of Utah's western deserts. Identification and analysis of these records allows the reconstruction of environmental change over the past 15,000 years. Understanding the history of this long-term change will help with future environmental management of the lands (see Survey Notes, volume 28, number 3, May 1996).

An initial survey of Camels Back Ridge in south-central Tooele County identified a small cave overlooking a chipped stone scatter. The scatter contained a basalt-stemmed point similar to those associated with the Western Stemmed Tradition. This tradition dates from approximately 11,000-8,000 years ago, indicating that the nearby cave may contain deposits extending back to the late Pleistocene age. The cave's elevation relative to regressive beaches of Pleistocene Lake Bonneville suggests that the cave was accessible to humans during the latter part of the post-Provo regression approximately 13,000 years ago.

Although the initial test excavations at Camels Back Cave revealed insufficient floral and faunal remains for pursuing the paleoenvironmental studies needed at that time, an extraordinary archeological site containing stratified



Map of the project area and site location.

deposits with hearths and human occupation surfaces extending back approximately 7,500 years was discovered. Deeper deposits are present below this early Archaic date, but were inaccessible because of time constraints and the limited size of the 1993 test trench. At least five living surfaces separated by eolian (wind blown) deposits were evident in the test-trench profiles, and it appeared that these

View of Camels Back Cave, location indicated by arrow.

surfaces could be clearly separated and analyzed in the course of detailed excavations. These deposits seemed to offer a unique opportunity for investigating a number of interrelated research topics in hunter-gatherer mobility and subsistence.

Camels Back Cave is one of the few stratified caves in the eastern Great Basin where, because of the absence of available water, individual visits by prehistoric peoples were most likely relatively brief. Most other well-known sites, such as Danger and Hogup Caves, are associated with spring and / or lakeside marsh deposits and contain relatively complex stratigraphic sequences resulting from long-term occupation.

Studies of the few remaining foraging societies (ethnoarchaeology) around the world have shown us that daily camp life is usually centered around cooking hearths, with the discarded material remains of many different activities distributed in and around the fire. Continuously used hearths are usually frequently cleaned. With each cleaning, the artifact patterns created during previous activities are swept aside, and the charcoal of yesterday's hearth is emptied as another day's refuse is distributed across the site. Where cave sites are heavily used, the activity area is limited by the cave walls and the refuse is found jumbled along the walls and strewn down the exterior slope at the mouth of the cave (not unlike sweeping house dirt out the front door). Because of this heavy use and constant cleaning, cave stratigraphy is often not clearly defined in separable layers, but is mixed and difficult to discern.

Camels Back Cave, however, appears to have been visited by people only briefly at widely spaced intervals. The material deposited between these visits is composed primarily of eolian dust, limestone roof spall, and the natural accumulations of small bones from the prey of raptors who regurgitated their meals while roosting on a ledge above the rock shelter. These culturally sterile layers served to protect the underlying cultural deposits from disturbance and contamination during visits by subsequent groups of hunter-gatherers. The alternating layers of cultural and non-cultural deposits form the classic layer-cake depositional sequence so often sought, but so rarely found, by Great Basin archaeologists.

Our excavation strategy is simple and straightforward. The horizontal and vertical provenance (source of origin) across the site is controlled by using a 50-centimeter-square (19.7 in) grid system measured from a known primary datum point. Working from exposed profiles, we horizontally expose each cultural surface (previously identified and dated during the paleoenvironmental testing phase) over an area 12 meters (39.4 ft) square. We map and photograph the distribution of artifacts and features across the surface, remove and analyze the larger, obvious artifacts, and retrieve and analyze one-liter-sediment samples from an area 50 centimeters (19.7 in) square. The sediment samples are separated in the laboratory using hand sorting and a flotation device to determine the distribution of very small floral and faunal remains, as well as the small waste flakes derived from the manufacture of stone tools (micro debitage).

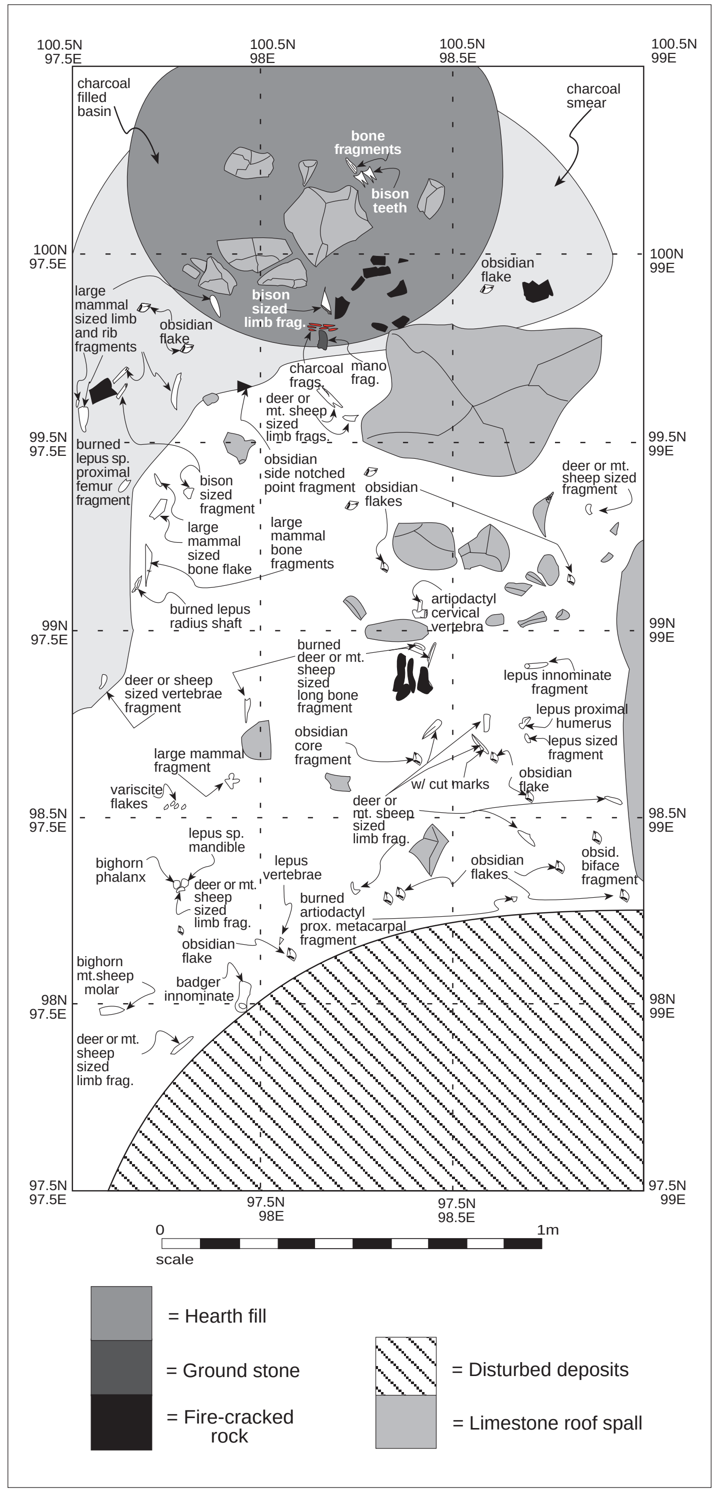
We are currently in the second year of a three-year project, and so far we have exposed and mapped two living surfaces dating to roughly 800 and 2,500 years ago. These living surfaces are composed of food-bone scrap, flaking debris, and a few broken and discarded tools centered around small hearths that give every appearance of representing individual short-term visits.

Our intention is to examine how long each of these living surfaces was occupied, as well as to look for variation in the use of the site through time. Generally, the results from the first-year excavation and analyses meet our research expectations. As with most excavations, however, there have been some unexpected results. The faunal material recovered from the site suggests local conditions may have from time to time been wetter than present. Environments with higher levels of precipitation support a wider mosaic of plants and a more diverse community of animals. In terms of human survival, these are more hospitable environmental conditions that promote extended stays of family-sized bands using a broader spectrum of foraging techniques, rather than small, mobile hunting parties using the site for shorter periods of time and then moving on when the plant and animal resources are depleted. Also, a large variety of stone tools was recovered, suggesting that there are distinct changes in the amounts and kinds of lithic material from one stratigraphic unit to another. These differences may also be related to changes in the use of the site through time, and imply changes not only for the site, but for the prehistoric use of the entire Dugway Proving Grounds area.

The different artifact classes recovered from the first-year excavations include awls for perforating tools, small bone and stone beads for decoration, waste from manufacture of bone beads, a variscite pendant, a scratched and polished large mammal long bone with a serrated end interpreted as a scraping tool, an incised bone gaming/counting piece used in gambling games, a few fragments of grinding stones for the processing of seeds, ceramic shards from vessels, as well as an array of projectile point types.

The identified animal remains found throughout the deposits include pygmy rabbits, rabbits and hares, Townsend's ground squirrel, smooth-toothed pocket gophers, Botta's pocket gopher, chisel-toothed kangaroo rat, Ord's kangaroo rat, deer mouse, white-footed mouse, bushy-tailed wood rat, desert wood rat, and the sage vole. The remains of carnivores recovered include the coyote, badger, and bobcat, and the artiodactyla (hoofed animals with an even number of toes) consist of mule deer, pronghorn, bison, and mountain sheep. Many of the smaller classes of animals yet to be identified include birds, lizards, and snakes.

The cultural chronology of Dugway Proving Ground is integrally related to the overall cultural history and paleo-ecology of the eastern Great Basin and, in turn, western North America; the earliest records of paleoclimate, ecology, and archaeology for this area are scant. We are hopeful that continued investigations of the lower levels of Camels Back Cave will produce the same kinds of living surfaces as those we have already mapped and recorded, and that we will be able to better define the lifestyles of the earliest Americans. The unique structure and preservation of the Camels Back Cave deposits provide an opportunity to expand our knowledge of the surrounding environment and history of the region as well as provide environmental managers with a broader understanding of the natural resources they control.

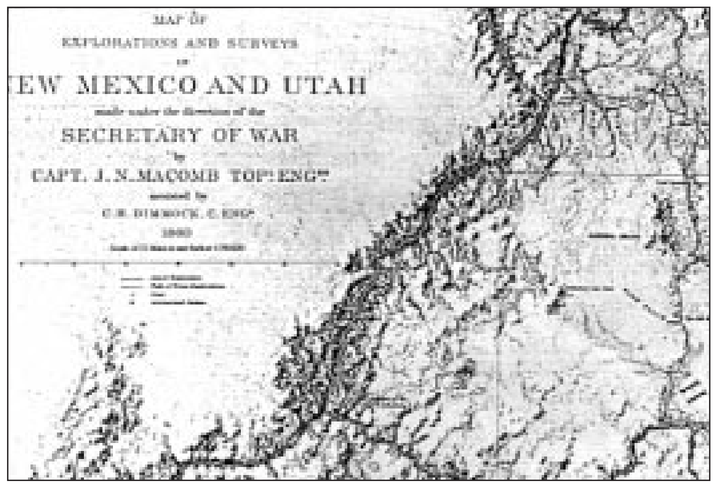


The exposed living surface of an 800-year-old Fremont camp at Camels Back Cave.

"Bad Bones, Bad Way"

by David D. Gillette and Martha C. Hayden

On a hot summer day 138 years ago (August 12, 1859), Captain John Macomb and his military exploration team from the U. S. Army Corps of Topographical Engineers established camp no. 26 in "Cañon Pintado" in what is now San Juan County, Utah. Among other goals, the expedition had been charged with locating the confluence "of the Grand and Green Rivers of the Great Colorado of the West." They had departed from Santa Fe, New Mexico and traveled by wagon and on horseback through southern Colorado. The group arrived at camp no. 26 after an arduous descent from the high plains of western Colorado and into the first set of canyons that lead to the spectacular region surrounding what is now Canyonlands National Park. Horses, wagons, weapons, food, maps, surveying equipment, and countless paraphernalia had to be let down the steep cliffs of "Cañon Pintado" in what was surely a hot and difficult day for soldiers accustomed to flatlands and organized military discipline.



Unpublished map of the Four Corners Area (what is now Utah, Arizona, Colorado, and New Mexico) produced by C. H. Dimmock in 1860 for the Macomb Expedition of 1859. The original of this large-format map is so large that details are lost at this level of reproduction.

John Strong Newberry, civilian naturalist from the Smithsonian Institution and medical doctor with a remarkable talent for finding fossils, found some fragments of fossil bone at the base of a steep, bare, red cliff of sandstone. Newberry scaled the slope by digging footholds into the sandstone and climbed higher and higher through multicolored levels of ancient sand dunes-turned-to-stone. Immediately above the valley floor where Newberry found the bone fragments lay several giant leg bones in a purple and red layer of siltstone. Newberry and his crew were astonished to find these "bones of a large saurian" as he later recorded in his journal.

Newberry had found the partial front leg of a giant "dinosaur," a term then not yet in popular usage. Other, smaller dinosaurs had been discovered in the East, and a couple had been discovered in modern Wyoming. Newberry probably did not know about the discoveries in Wyoming, but he was aware of the giant saurians of England and the eastern United States that included carnivores and duck-billed dinosaurs as they are known today.

Compared to modern land-dwelling animals, these dinosaurs were large, but the giants among the giants were the sauropod dinosaurs. Newberry may have been the first scientist in the world to discover a sauropod. His "large saurian" was almost certainly the first sauropod discovered in North America, where the infamous rush to the American West would begin a decade later and culminate in the dinosaur "war" between two bigger-than-life paleontologists, Othniel C. Marsh of the Yale Peabody Museum, and Edward Drinker Cope, an independent paleontologist and naturalist from Philadelphia. These antagonists dueled for prominence for nearly three decades. One would play a key role in Newberry's discovery, but not until nearly 20 years after Macomb's Army had visited the remote canyonlands of southern Utah.

On the return trip through "Cañon Pintado" 11 days later,

◀ *Details of the route taken by the Macomb Expedition on the Dimmock map (shown above) indicate the location of camp 26. This map proved critical to Fran Barnes in his search for the type locality of the dinosaur that Newberry discovered in "Canyon Pintado."*

▶ *Fran Barnes at the type locality of Newberry's dinosaur, Dystrophaeus viaemalae.*

Newberry carefully extricated the bones from the shale and the team carried the bones down the steep and dangerous slopes to the valley floor. They then packed the bones, labeled them, and stowed them safely in the wagons. The bones had begun a long journey that took them away from the maze of canyons and cliffs in the tributaries of the Rio Colorado. Eventually the bones were delivered to the Smithsonian Institution in Washington, D.C. under Newberry's care. Soon after returning from the expedition, Newberry joined the Union Army in the Civil War as a medical doctor. His paleontological endeavors interrupted by his duty to the United States and medicine, he never returned to the remarkable bones from "Cañon Pintado." Newberry's "large saurian" bones laid unstudied for nearly two decades.

Meanwhile, Cope's war with Marsh had begun and had escalated. These brilliant and eccentric paleontologists published at a frenetic pace, at times averaging one technical paper a day for weeks on end. Newspapers printed their exploits with excruciating and often embarrassing detail. The dinosaur rush in the West took on epic proportions. Excavation crews spied on each other, individual members were "persuaded," with rewards too great to refuse, to defect to the opposite camp, and labels were switched as crates were loaded onto trains for shipment. As these two giants waged war to win prominence and glory, no price was too great, no connivance was too outrageous.

In 1877, one of Cope's brilliant publications described John Strong Newberry's "giant saurian" leg bones as belonging to the front limb of a sauropod dinosaur from the Triassic redbeds of Utah. Cope named the bones *Dystrophaeus viaemalae*, a puzzling combination of Latin and Greek that seems to mean "bad bones, bad way," apparently referring to the hard and difficult climb to recover the fossils bones on the cliffs in "Cañon Pintado." Newberry's bones became the type specimen for this enigmatic sauropod.

Again, the bones languished in the Smithsonian Institution Museum of Natural History as specimen number USNM (U.S. National Museum) 2364, this time for more than two decades. In 1904, German paleontologist Frederich von Huene redescribed the bones and correctly inferred that their age was Jurassic, not Triassic as Cope had reported. Later paleontologists recognized that Newberry's dinosaur must have originated from the Upper Jurassic Morrison Formation of southern Utah, but even in Cope's time the exact locality information had been forgotten and lost. No one, including von Huene, could verify or improve on what Newberry had left in the archives at the Smithsonian.

For a third time, the bones languished, this time for 70 years. No one knew the location of the type locality, or even the correct location of "Cañon Pintado." No canyon by this name exists on modern maps of southeastern Utah. Fran Barnes, a local historian and naturalist from Moab, Utah, learned about Newberry's fossils in the mid-1970s and began a long quest to find the type locality. His quest became a passion. With his wife, Terby, Fran sought out the journals and unpublished documents of the Macomb Expedition in Washington, D.C. in the National Archives and other national repositories for official documents. Fran's detective work took 12 years and countless trips to the canyons of southeastern Utah. His simultaneous search of the archives and the canyons finally proved fruitful in 1988.

On a steep slope in East Canyon in San Juan County, Fran located some fossil bones in the Morrison Formation that seemed to fit all the information he had accumulated in his persistent search. He called the office of State Paleontology (the authors) in 1989 to report on his search and declare that he thought he had found Newberry's site. We agreed to visit him in Moab to review his evidence. Just the recognition of the location of the type locality was sufficient reason to pursue Fran's claim. We had no idea that the site would have more than historical significance.

Bones from the front foot of Dystrophaeus viaemalae.

Fran pulled out his extensive and meticulously documented archives, including important unpublished maps. He told his story in fine detail. Then he led us to East Canyon, and ultimately to the site where he had found fossil bones in the Morrison Formation. The climb to the bones was steep and difficult. The bones were in a siltstone low in the Morrison. We searched in vain up and down the canyon for other fossil bones. We reviewed Fran's evidence again. We needed more information to confirm Fran's conclusion. We asked paleontologists at the Smithsonian Institution Museum of Natural History to locate Newberry's bones and send us archival information. To our great surprise, we learned that the bones were in Utah, at the Earth Science Museum at Brigham Young University (BYU). BYU dinosaur paleontologist Jim Jensen and sauropod expert Jack McIntosh had tried a few years earlier to establish the type locality of *Dystrophaeus viaemalae* when they had borrowed the bones for study. Newberry's dinosaur bones had returned to Utah, but their travels were not yet finished.

We compared the bones of the type specimen with the bones at Fran's site. They had identical preservation and the rocks associated with the bones were a perfect match. All that remained was to confirm the bones still in place in East Canyon as dinosaur. We conducted a short excavation in 1989, and satisfied ourselves beyond doubt that this was the correct location. Our team had located the original home of *Dystrophaeus viaemalae*, Newberry's "Bad Bones, Bad Way."

The story was not finished. We discovered that the site is in the Tidwell Member of the Morrison Formation, far below and much older than the members of the Morrison that have yielded North America's phenomenal bounty of Jurassic dinosaurs. *Dystrophaeus viaemalae* is not only the first dinosaur discovered in Utah and the first sauropod discovered in North America and perhaps in the world. It is also the oldest sauropod known in North America. No sauropods existed in North America until they immigrated from other continents in the Late Jurassic. The type locality of Newberry's dinosaur represents the entry of sauropods into North America, an event that led to the phenomenal diversification and abundance of dinosaurs of the Colorado Plateau from the Late Jurassic until the end of the Cretaceous Period.

Beginning this year, we expect to renew excavations at the type locality of the "Bad Bones, Bad Way" dinosaur. The original bones were transferred from BYU to the Utah Division of State History in the Rio Grande Building in Salt Lake City a few years ago, where they were used for study and placed on display. Today the bones are on display at the Vernal Field House of Natural History State Park with a photographic exhibit that recounts the long and colorful history of paleontology in Utah. The bones still belong to the Smithsonian Institution, which is their permanent repository. But for now, "Bad Bones, Bad Way" have a foster home, in their own home state. The story of *Dystrophaeus viaemalae* from "Cañon Pintado" is not over. The next problem to solve is its true identity: is this dinosaur one of the ones we know already, such as *Camarasaurus, Apatosaurus, Diplodocus, Barosaurus, Haplocanthosaurus, Supersaurus, Seismosaurus,* or *Brachiosaurus?* Is it altogether different? Which continent did its ancestors come from? Only excavation can answer these questions. The mystery continues.

For further reading:

Barnes, F.A., 1988, Canyonlands National Park -- Early History and First Descriptions: Canyon Country Publications, Moab, Utah, 160 p. (ISBN 0-9614586-2-3).

Gillette, D.D., 1996, Origin and early evolution of the sauropod dinosaurs of North America -- the type locality and stratigraphic position of *Dystrophaeus viaemalae* Cope 1877, *in* Huffman, A.C., Lund, W.R., and Godwin, L.H., editors, Geology and resources of the Paradox Basin, Utah Geological Association Guidebook 25: 313-324.

Gillette, D.D., 1996, Stratigraphic position of the sauropod *Dystrophaeus viaemalae* Cope and its evolutionary implications, *in* Morales, Michael, editor, The continental Jurassic, Museum of Northern Arizona Bulletin 60: 59-68.

Utah's Newest Big Landslide

by Francis X. Ashland

A new geologic feature, the Shurtz Lake landslide, can be viewed by motorists traveling between Price and Spanish Fork along Utah Highway 6. The landslide is located on the northeast side of a mountain south of the highway and upstream of the confluence of the Spanish Fork River and Diamond Fork. Numerous older nearby landslides indicate this slope has been unstable in the past, and the lower part of this recent landslide reactivated some of the older landslide deposits. According to Utah Power & Light (UP&L), landslide movement began on Tuesday, May 6, 1997, and disrupted power transmission on two sets of high-voltage power lines that cross the slide. As a result of ground movement, four transmission poles were displaced and tilted. Tilting and downslope movement of the upslope set of poles was so severe that transmission was discontinued and the power lines abandoned. Preliminary estimates suggest the landslide is about 3,000 feet long and 4 million cubic yards in volume. To put those numbers in perspective, that makes it about one-seventh the size of the infamous 1983 Thistle slide located a mile to the south. The Thistle slide caused over $200 million in damage as it blocked the Spanish Fork River.

The most visible features in the Shurtz Lake landslide are three earth flows that formed on the steepest part of the slope. The earth flows formed levees on their sides and "bulldozed" soil and vegetation in their path. Layers of soil below the earth flows are shoved on top of each other as a result. Most of the landslide is above the earth flows and can't be seen well from the highway. Numerous ground cracks, scarps and offset tree lines in this area suggest about 40 or so feet of spreading. Since May 6, only gradual movement has been detected by UP&L and the Utah Geological Survey (UGS). However, new ground cracks and features continued to appear farther downslope, suggesting the area of landslide movement was enlarging and extending downward toward the Spanish Fork River. Periodic monitoring of the slide is being conducted by Utah County and the UGS to determine if the slide represents a continuing hazard.

The Shurtz Lake landslide on May 9, 1997. Dashed line shows approximate boundary of landslide. View is to the south from Utah Highway 6. Spanish Fork River is visible in bottom of photograph.

Transmission pole tilted by landslide movement. Pole is one of two in upslope set of transmission poles on landslide. Downslope movement caused one of three powerlines to be severed from pole. Powerlines were subsequently abandoned.

Massive Erosion Near Vernal

by Gary E. Christenson

On Sunday, May 18, 1997, red sediment began to choke irrigation canals in the Vernal area, and by nightfall it was apparent a major sediment-producing event had occurred somewhere upstream in Dry Fork Canyon. By Monday, May 19, diversion structures in Dry Fork were damaged by erosion and sedimentation, the highway up Dry Fork Canyon was flooded, and sediment was plugging canals, pressure-irrigation systems, and the water treatment plant serving Maeser.

Emergency investigations revealed two newly created, massive erosional ravines in the east side of Mosby Mountain, 23 miles northwest of Vernal, in the upper Dry Fork drainage of the Uinta Mountains. Near the head of the ravines, water from a breach in a mountain-top irrigation canal had flowed over the canyon wall into Dry Fork. Flow initially cut two ravines, but all of the flow was later captured and concentrated into one ravine. As the ravine cut down, large blocks from its walls collapsed into the ravine and disintegrated. This material, and material eroded from the bottom, was transported in a thick sediment slurry and deposited in an alluvial fan on the floodplain of Dry Fork. By the time the canal breach was repaired on Tuesday afternoon, May 20, the ravine was about 250 feet deep at its deepest point, up to 500 feet wide, and about 2,400 feet long. About 1.5 million cubic yards of material was removed from the canyon wall and delivered to the floodplain of Dry Fork. The alluvial fan at the base of the larger ravine forced Dry Fork against the opposite canyon wall and partially blocked the stream, forming a small pond upstream.

Geologically, one of the most remarkable features revealed by this event was the tremendous thickness of highly erodible material in the steep walls of Dry Fork Canyon. As a result of the event, increased sediment loads and channel instability can be expected in Dry Fork for years to come, particularly during storms and spring snowmelt periods. Walls of the ravines will likely remain unstable for many years.

Westward aerial view of erosional ravines and alluvial fans in Dry Fork Canyon.

Eastward aerial close-up view looking downstream - deepest part of larger ravine.

The Rockhounder

by Mark R. Milligan

Horn Corals, Crinoids, and Brachiopods in the Lakeside Mountains, Tooele County

Geologic information: Approximately 350 million years ago (Mississippian Period), warm, shallow seas rich with life covered most of Utah. West of Salt Lake City these waters deposited the limestone of the Deseret Formation exposed in the steep slopes of the Lakeside Mountains. Fossils found in this limestone include: crinoids or sea lilies, two-valved seashells called brachiopods, and colonial and solitary coral. Perhaps the most collected of these fossils is the now extinct solitary rugose coral which resemble a cow's horn, thus the common name - horn coral.

How to get there: From Salt Lake City take I-80 west approximately 50 miles to Delle (exit 70). Turn right at the end of the off ramp, then left to follow the frontage road west for approximately 3 miles until the road turns right (northeast). After crossing the railroad tracks, take the right fork and continue 3.4 miles up the main dirt road. Turn left onto a less-traveled dirt road and continue approximately 1/2 mile until the road ends at the base of the peak with radio towers (Black Mountain).

Where to collect: Specimens can be found in the gray ledge-forming limestone on the southern slopes of Black Mountain. The horn corals have been silicified (original shell material replaced by silica) and stand out in relief from the surrounding rock. Many specimens are locked in the rock's matrix. Please do not attempt to remove such fossils; ample collectable samples can be found loose on the ground in rubble at ledge bases.

Useful maps: Tooele 1:100,000-scale topographic map, Delle 1:24,000-scale topographic map, and a Utah highway map. Topographic maps can be obtained from the Natural Resources Bookstore, 1594 W. North Temple, Salt Lake City, UT, (801) 537-3320.

Land ownership: The described collecting location is on Bureau of Land Management (BLM) public lands. Other potential collecting areas in the Lakeside Mountains may be located on School and Institutional Trust Land (state land) or private land. Any collecting done on state land or private land will require a permit or special permission, respectively.

BLM collecting rules: The casual collector may take small amounts of invertebrate fossils, petrified wood, gemstones, and rocks from unrestricted federal lands in Utah without obtaining a special permit if collection is for personal, non-commercial purposes. Collection in large quantities or for commercial purposes requires a permit, lease, or license from the BLM.

Precautions, miscellaneous: A large, open, vertical mine shaft is located at this site, near the end of the road. The edge of the shaft may be unstable and should not be approached. Use extreme caution if children are with you. Gloves, sturdy shoes, and long pants are highly recommended protection against the rough surfaces of grooves and knifelike ridges (karrenfeld) that characteristically develop on weathered limestone surfaces. Use caution on the steep slopes, always carry plenty of water, and use sunscreen. Please carry out your trash. Have fun and enjoy the rocks!

Silicified horn coral weathered out in relief from limestone of the Deseret Formation, exposed in the Lakeside Mountains. Car key for scale.

Survey News

Welcome to new employees **John Hanson**, **Mike Sheehan**, **Ron Neeley, Chris Eisinger and Rebecca Gonzales**. John is the newest member of the Economic Geology Program, replacing Bob Blackett, who transferred to Cedar City to serve on the Bureau of Land Management team developing the comprehensive management plan for the Grand Staircase-Escalante National Monument. John's experience is in environmental consulting, hydrogeology and geographical information systems. He has a BS in Geology from the University of Texas and most recently worked with Operational Technologies Corporation at the Paduch, Kentucky, gaseous diffusion plant to evaluate radionuclide burial and extent of groundwater contamination. Mike is a fulltime Revenue Technician in the Natural Resources Map & Bookstore. His background is in sales with AT&T and Pier 1 Imports. Ron is the new person helping at the Sample Library. He comes to us from State Archives. Chris and Rebecca have just joined the Environmental Sciences group as geologic technicians for the water program. Welcome!

Doug Sprinkel (Economic Geology Program) was the featured presenter at the July Utah Geological Association meeting. "A Preliminary Petroleum System Analysis, Central and South-central Utah," was co-authored by the late John R. Castano of DGSI, Houston, Texas; and Kimberly M. Stevens and George W. Roth of Hunt Oil, Dallas, Texas. The report concluded that the central and south-central region of Utah may be under-explored for Permian, Triassic, and Cretaceous reservoirs.

Craig Nelson was confirmed by the Utah Senate as the newest UGS Board member representing engineering. He is an engineering geologist in Salt Lake and formerly was the Salt Lake County Geologist. Craig fills the slot left vacant by Milton Wadsworth.

Bookstore Manager **Vicki Whitaker** has left to go back to school to get a teaching certificate. Vicki was instrumental in bringing the Bookstore through its expansion of size, content, and staffing and dramatically increasing its sales volume. She will be greatly missed.

Energy News

Oil Demonstration Programs Move Into Advanced Phases

Three programs funded in part by the Department of Energy and managed by the Utah Geological Survey's Economic Geology Section are nearing important progress milestones. The three programs are the Bluebell field demonstration, the Ferron Sandstone 3-D reservoir simulation, and the Paradox Basin study. Craig D. Morgan is the project manager for Bluebell. Thomas C. Chidsey, Jr., is the project manager for Ferron and Paradox. A fourth DOE program in the Midway-Sunset field in the San Joaquin Basin of California is managed by the Energy and Geoscience Institute at the University of Utah with the stratigraphic work subcontracted to the UGS's Douglas A. Sprinkel.

The Bluebell demonstration is designed to demonstrate economical increases in petroleum production through the use of geologic analysis and modern oil field technology. Located in the Uinta Basin, the field already produces oil from the Tertiary Green River and Wasatch Formations. During its first three years, the project consisted of an intense geological and reservoir characterization study of the field. Work is now underway on the demonstration phase, which includes re-completing an existing well that experienced formation damage during drilling operations, selecting and separately stimulating three or more beds in a second existing well, and drilling a new well.

The Ferron project is a geoscience/engineering study seeking to develop a comprehensive, interdisciplinary, and quantitative characterization of a river-dominated delta which will allow realistic inter-well and reservoir-scale modeling for improved oil field development in similar reservoirs. The project began with a regional stratigraphic analysis of the Ferron Sandstone outcrop belt in Emery County, then moved into case studies. Now developing reservoir models, the project will next simulate three-dimensional oil flow using reservoir properties within the Ferron Sandstone. The model and simulation results can be applied to oil-bearing fluvial-deltaic reservoirs throughout the United States. This type of reservoir is the most productive in the country.

The Paradox Basin study seeks to enhance domestic petroleum production by demonstration and technology transfer of an advanced, secondary oil-recovery technology, where water or carbon dioxide gas is injected into a reservoir to force remaining oil to a recovery well. It involves the first-ever attempts in Utah to drill horizontal wells in small algal-mound reservoirs. If this project can demonstrate technical and economic feasibility, the technique can be applied to approximately 100 additional small fields in the Paradox Basin alone, and result in increased recovery of as much as 200 million barrels of oil. The Paradox Basin is located in the southeastern corner of Utah.

The Midway-Sunset project is an attempt to reactivate an idle well to increase heavy oil recovery through the application of conventional steam-drive technology. The objectives are to accurately describe the reservoir and recovery process, return the shut-in portion of the reservoir to commercial production, and convey the details of this activity to the domestic industry. The first phase has been successfully completed and the project is now moving to the second. Expected recoverable reserves are 550,000 barrels of oil in the test area. Additional recoverable reserves from the full property may be 3 million barrels or more.

For more information about these projects, check the UGS website at http://www.ugs.ut.us.

Conoco Begins Drilling in GSENM

Conoco, Inc., received approval from the Utah Division of Oil, Gas and Mining to drill one deep (>14,000 feet) wildcat well on a state lease located within the Grand Staircase-Escalante National Monument. Conoco controls about 140,000 acres of leases within the monument and another 85,000 acres on adjacent lands. The well is designed to test the Precambrian Chuar Group and Cambrian Tapeats Sandstone, an exploratory "play" concept first identified by the UGS in 1989. In June, Conoco moved its drilling equipment to a site on Utah School and Institutional Trust Lands in Reese Canyon. The well site is located on the Reese Canyon anticline, which is one of nearly 30 geologic structures that geologists have identified as having significant oil and gas potential within the new monument. According to UGS estimates, the monument could contain as much as 10 trillion cubic feet of coalbed methane gas, 270 million barrels of oil, and 4 trillion cubic feet of carbon dioxide gas.

Utah's Oil and Gas Sector Shows Healthy Gains in 1996

A rising trend in crude oil and natural gas prices spurred activity in Utah's oil and gas sector. Data from the Division of Oil, Gas and Mining indicate that the state experienced a substantial gain in drilling activity in 1996. The division issued 396 drilling permits last year, the highest level in four years. Of that total, 255 permits were for oil wells, 99 for gas wells, and 15 for either injection or disposal wells. A total of 247 wells were completed in 1996; of those, 180 were development wells within existing fields, 44 were extended wells (step-outs near existing fields), and 23 were wildcat wells. The four most active counties by number of drilling permits issued were Duchesne, with 170; Uintah, with 86; Carbon, with 38; and San Juan, with 36. Utah produced 19.5 million barrels of oil and 281.8 billion cubic feet of gas in 1996, a slight decrease from 1995.

. . . Director's Perspective continued.

whether we will see large-scale mining and drilling in the monument. And it is not necessarily our intent that such development take place. But if it does not, then the federal government has an obligation to fairly compensate the land-owners and royalty-owners for their lost potential revenues. By identifying the type, amount, and availability of resources in the monument, the UGS is helping to ensure that state and private owners have the best information to defend their interests.

If significant development is not allowed in the monument, the monument planners should consider preserving the resources for some future use. A Kaiparowits National Strategic Coal Reserve could be established with development allowed only if and when the President declares a national emergency. In order to make use of such a reserve, the monument plan and subsequent management would have to ensure that nothing is done that would preclude the development of the reserve when it is needed. A similar National Petroleum Reserve and National Strategic & Critical Mineral Reserve (for titanium) could also be established.

An alternative approach could be to allow the GSENM to become a "working" monument. Royalties from developing the vast energy and mineral resources could be directed to a national parks trust fund for preservation, maintenance, and enhancement of parks and monuments around the country. Even conservative estimates of coal production from the Kaiparowits coal field would result in over $9 billion in royalties to the federal government over the life of production. An equal amount would flow to state coffers under existing laws. Presently the federal share of royalties goes to the reclamation fund so it would take Congressional action to divert it to a national parks trust fund.

The monument is unique in that the Bureau of Land Management is the managing agency. BLM manages much of its lands under a multiple-use policy. It is likely the monument will have different uses in different areas - tourism, facilities, and camping in some areas, wilderness or limited access in others, and perhaps controlled development in selected locales. The differences between a "working" monument and other park units with development would be one of philosophy and where the royalties go.

"Glad You Asked"

by Mark R. Milligan

"How do geologists know how old a rock is?"

Geologists generally know the age of a rock by determining the age of the group of rocks, or formation, that it is found in. The age of formations is marked on a geologic calendar known as the geologic time scale. Development of the geologic time scale and dating of formations and rocks relies upon two fundamentally different ways of telling time: relative and absolute. Relative dating places events or rocks in their chronologic sequence or order of occurrence. Absolute dating places events or rocks at a specific time. If a geologist claims to be younger than his or her co-worker, that is a relative age. If a geologist claims to be 45 years old, that is an absolute age.

Relative Dating

The most basic concept used in relative dating is the **law of superposition**. Simply stated, each bed in a sequence of sedimentary rocks (or layered volcanic rocks) is younger than the bed below it and older than the bed above it. This law follows two basic assumptions: (1) the beds were originally deposited almost horizontally, and (2) the beds were not overturned after their deposition.

Similar to the law of superposition is the **law of faunal succession**, which states that groups of fossil animals and plants occur throughout the geologic record in a distinct and identifiable order. Following this law, sedimentary rocks can be "dated" by their characteristic fossil content. Particularly useful are index fossils, geographically widespread fossils that evolved rapidly through time.

Relative ages of rocks and events may also be determined using the **law of crosscutting relationships**, which states that geologic features such as igneous intrusions or faults are younger than the units they cut across. **Inclusions**, which are fragments of older rock within a younger igneous rock or coarse-grained sedimentary rock, also facilitate relative dating. Inclusions are useful at contacts with igneous rock bodies where magma moving upward through the crust has dislodged and engulfed pieces of the older surrounding rock.

Gaps in the geologic record, called **unconformities**, are common where deposition stopped and erosion removed the previously deposited material. Fortunately, distinctive features such as index fossils can aid in matching, or **correlating**, rocks and formations from several incomplete areas to create a more complete geologic record for relative dating.

Relative dating techniques provide geologists abundant evidence of the incredible vastness of geologic time (see chart) and ancient age of many rocks and formations. However, in order to place absolute dates on the relative time scale, other dating methods must be considered.

Absolute Dating

The nuclear decay of radioactive isotopes is a process that behaves in a clock-like fashion and is thus a useful tool for determining the absolute age of rocks. **Radioactive decay** is the process by which a "parent" isotope changes into a "daughter" isotope. Rates of radioactive decay are constant and measured in terms of **half-life**, the time it takes half of a parent isotope to decay into a stable daughter isotope. Some rock-forming minerals contain naturally occurring radioactive isotopes with very long half-lives unaffected by chemical or physical conditions that exist after the rock is formed. Half-lives of these isotopes and the parent-to-daughter ratio in a given rock sample can be measured, then a relatively simple calculation yields the absolute (radiometric) date at which the parent began to decay, i.e., the age of the rock.

Of the three basic rock types, igneous rocks are most suited for radiometric dating. Metamorphic rocks may also be radiometrically dated. However, radiometric dating generally yields the age of metamorphism, not the age of the original rock. Most ancient sedimentary rocks cannot be dated radiometrically, but the laws of superposition and crosscutting relationships can be used to place absolute time limits on layers of sedimentary rocks crosscut or bounded by radiometrically dated igneous rocks.

Sediments less than about 50,000 years old that contain organic material can be dated based on the radioactive decay of the isotope Carbon 14. For example, shells, wood, and other material found in the shoreline deposits of Utah's prehistoric Lake Bonneville have yielded absolute dates using this method. These distinct shorelines also make excellent relative dating tools. Many sections of the Wasatch fault disturb or crosscut the Provo shoreline, showing that faulting occurred after the lake dropped below this shoreline which formed about 13,500 years ago. As this example illustrates, determining the age of a geologic feature or rock requires the use of both absolute and relative dating techniques.

Geologic Time Condensed into One Calendar Year	
January 1	*Earth formed*
April 7	*Life (bacteria and blue-green algae) first appeared*
November 15	*Trilobites swam along the ocean bottom west of Delta, now fossilized in the Wheeler Shale*
December 15	*Sand-dune fields blew across Utah, now the buff-red cliffs of Navajo Sandstone*
December 19	*Dinosaurs roamed eastern Utah, bones now fossils in the Morrison Formation*
December 26	*Major coal-forming swamps and marshes existed, now the Black Hawk Formation exposed in the Book Cliffs between Price, Utah and Grand Junction, Colorado*
December 27	*Lakes deposited the multicolored rocks of Bryce and Cedar Breaks*
December 30, 6:43 p.m.	*Wasatch fault started moving*
December 31, 11:58:13 p.m.	*Lake Bonneville covered much of western and northern Utah*
December 31, 11:58:29 p.m.	*First humans appeared in Utah*
December 31, 11:59:56 p.m.	*Most recent volcanic eruption in Utah, now the basalt in the Black Rock Desert west of Fillmore*
December 31, 11:59:57 p.m.	*Most recent large earthquake on the Wasatch fault*
December 31, 11:59:59 p.m.	*Pioneers reached the Salt Lake Valley*

Charles B. Hunt, Long-time Utah Geologist, Dies at Age 91

by Grant C. Willis

The Utah geologic community lost a great friend and mentor with the death of Charles Butler Hunt on September 3, 1997. Though Charlie spent most of his life with the U.S. Geological Survey, Utah has always considered him one of our own, since most of his work was within the borders of the state.

Charlie was born August 9, 1906 in West Point, New York. He gained his education at Colgate and Yale Universities, and in 1930 joined the U.S. Geological Survey. One of his first projects was to map the geology along the Colorado River with the reknowned geologist C.H. Dane. He mapped the Henry Mountains when they were still true frontier, with few roads and no bridges. Later, he published landmark papers on the La Sal Mountains and on Lake Bonneville. His work on the Colorado Plateau led to two of his greatest contributions to geology, USGS Professional Paper 279, Cenozoic geology of the Colorado Plateau, and Professional Paper 669, Geologic history of the Colorado River, in which he developed many of the modern concepts on the evolution of the Colorado River drainage. He also authored a 725-page book on the Natural Regions of the United States and Canada.

After his retirement from the USGS in 1959 he joined the faculty at John Hopkins University, and later was a distinguished visiting professor at New Mexico State University and a Visiting Scholar at the University of Utah. Charlie's knowledge and understanding of Utah geology were widely recognized. He served the local geologic community in many ways, such as, serving as a member of the group that analyzed the proposed sites in southern Utah for the high-level radioactive waste repository

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New Publications of the UGS

Effect of geothermal drawdown on sustainable development, Newcastle area, Iron County, Utah, by R.E. Blackett, H.P. Ross, and C.B. Forster, 31 p., 8/97, C-97 . . $5.00

1996 summary of mineral activity in Utah, by R.L. Bon, R.W. Gloyn, and D.E. Tabet, 12 p., 8/97, C-98 . . . . $3.40

Earthquakes & Utah, by Sandra Eldredge, 6 p., 8/97, PI-48 . . . . Free

Utah gold: history, placers, and recreational regulations, by C.M. Wilkerson, 9 p., 8/97, PI-50 . . . . $1.00

Brine properties, mineral extraction industries, and salt load of Great Salt Lake, Utah, by J.W. Gwynn, 2 p., 6/97 PI-51 . . . . Free

Utah Geological Survey information brochure, flyer, 8/97, PI-52 . . . . Free

Stability of the Pine Ridge landslide at Timber Lakes Estates, Wasatch County, Utah: implications for future development and land-use planning, by F.X. Ashland and M.D. Hylland, 4 p., PI-53 . . . . Free

Report to the Utah Geological Survey on the 1996 Gobi-Altay, Mongolia, paleoseismology expedition, by W.R. Lund, 14 p. + appendix, 4/97 RI 233 . . . . $2.00

Reconnaissance of the Shurtz Lake landslide, Utah County, Utah by F.X. Ashland, 22 p., 7/97 RI-234 . . . . . $2.50

Preliminary geotechnical-engineering slope-stability investigation of the Pine Ridge landslide, Timber Lakes Estates, Wasatch County, Utah, by F.X. Ashland and M.D. Hylland, 29 p., 7/97 RI-232 . . . . $3.00

Bridgeland and South Myton Bench oil fields, T. 4 S., R.2 and 3 W., UBM, Duchesne County, Utah by C.D. Morgan, 2 sheets, 9/97, OG-17 . . . . $10.00

Duchesne oil field, T. 4 S., R.4 and 5 W., UBM, Duchesne County, Utah by C.D. Morgan, 2 sheets, OG-16 . . $10.00

Humpback secondary-recovery (water-flood) unit, T. 8 S., R.17 E., Salt Lake Base Line, Uintah County, Utah by C.D. Morgan, 2 sheets, 9/97, OG-18 . . . . $10.00

Progress report geologic map of the Ogden 30' x 60' quadrangle, Utah and Wyoming - year 1 of 3, by J.C. Coogan and J.K. King, 23 p., 1 pl., scale 1:100,000, 9/97, OFR 350 . . . . $5.00

Interim geologic map of the Valley City quadrangle, Grand County, Utah, by H.H. Doelling, 64 p., 2 pl., 1:24,000, 9/97, OFR-351 . . . . $10.50

Complete Bouguer gravity anomaly map and geological interpretation of the southern Wasatch Front, Utah, by K.L. Cook, D.A. Edgerton, L.F. Serpa, and Michael DePangher, 20 p., 1 pl., scale 1:100,000, 9/97, CR-97-1 . . . . $5.00

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Teacher's Corner

Teacher's Day Program - May 1998

Receive credit and classroom-ready materials at a special science convention in Salt Lake City, May, 1998.

Teachers will have a unique opportunity in May, 1998 to attend the American Association of Petroleum Geologists (AAPG) annual convention in Salt Lake City. In recognition of the importance of science education, several years ago the AAPG established a Teacher Day Program in their conventions and the day in 1998 will be May 18, with an additional day of field trips on Saturday, May 16 - all in the Salt Lake area (last year's convention was in Dallas with about 90 teachers attending). Teachers will be guests of the AAPG.

Saturday: Your choice of field trips are:

Geology along the Wasatch Front and Little Cottonwood Canyon led by Ivan Dyreng, former East High School geology teacher who has led numerous and extremely popular field trips for teachers.

SEND THE RESPONSE FORM TO AAPG

Geology of Antelope Island and Dynamics of Great Salt Lake led by two enthusiastic scientists from the Utah Geological Survey: Bill Case who has extensive experience teaching teachers and Wally Gwynn, our "Great Salt Lake expert" who wrote an all-encompassing book on the lake.

Monday: You may attend one or two workshops (both are available for credit):

Rocks in Your Head, a nationally acclaimed workshop that will be specially designed for Utah teachers to meet the state's new core curriculum standards for grades 3 - 9.

Antelope Island and Great Salt Lake Earth Systems will be a continuation of the field trip (or you may take this separately if you wish) and designed for science teachers of several disciplines including geology, chemistry, and biology.

In addition to the workshops, you will have an opportunity to network with peers, converse with geoscientists, tour the exhibit hall, and listen to scientific presentations. Breakfast and lunch will be provided.

Registration and Information: Look for the flier that will be in your fall Utah Science Teacher Resource Portfolio. Make sure you send in the flier-response form to AAPG, and then you will be contacted in the winter for final registration. If you want further information, please contact Sandy Eldredge at phone 801-537-3325, fax 801-537-3400, E-mail nrugs.seldredg@state.ut.us.

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now being developed at Yucca Mountain, Nevada. He also was recognized nationally and served in many national organizations, including as Executive Director of the American Geological Institute from 1953 to 1955.

Charlie was not only known for his scholarly accomplishments, but also for his sense of humor. In 1939, he coined the term "cactolith" as a satirical jab at the "absurd" geologic terms that were proliferating faster than rabbits, and at the many geologists who seemed to take themselves a little too seriously. Later, he published the comical, yet insightful, "How to Collect Mountains", and "Dating Mining Camps with Tin Cans and Bottles", the latter of which, though not intended at the time, turned out to be a valuable contribution to archeological methods.

All who knew him will miss Charlie's warm sincerity and delightful sense of humor. The Spring 1989 edition of Survey Notes contains an interesting biography for those who would like to read more about Charlie and his career.

The Geological Society of America

International Program 1997

October 18 - 23, 1997

The Salt Lake Organizing Committee has invited geologists from national geological surveys around the globe to participate in an international program in conjunction with the 1997 Annual Meeting.

Technical Poster Session • Exhibits • Plant Tours
Site Visits • Hosted Reception

Learning from the Land

Scientific Inquiry for Planning and Managing the Grand Staircase-Escalante National Monument

November 3 - 7, 1997 • Southern Utah University

A two-day symposium on the scientific inquiry of geological structure, stratigraphy, paleontology and archeology, and diverse biological resources of the Grand Staircase-Escalante National Monument.

Several field trips are scheduled Saturday, Sunday and Monday prior to the symposium.

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Survey Notes

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